Age effects on cognitive, neural and affective responses to emotional facial expressions

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Abstract

Empathic reactions to emotional facial expressions differ according to age. Concerning the cognitive component of empathy, decoding of emotional facial expressions was reported to be impaired both for older observers and older faces. Some studies also reported an own-age advantage, i.e., higher decoding accuracy for facial expressions of the own compared with other age groups. The first aim of the present dissertation was to explore possible mechanisms underlying these age effects on cognitive empathy. The second aim was to explore whether the affective component of empathy is affected by age as well. The present dissertation is based on four studies. Study 1 summarizes previous research on age effects on decoding accuracy and possible underlying mechanisms, with a focus on the age of the face. Two of these mechanisms were empirically examined in the present dissertation. Study 2 explored the role of age-related response bias, that is, age differences in the attribution of specific emotions. It showed that effects of the observers' and the faces' ages on decoding sadness were due to age-related response bias. However, an own-age advantage on decoding sadness occurred, which was independent of response bias. Study 3 explored the neurofunctional processes underlying this own-age advantage. It revealed an own-age effect on late neural processing stages for sadness, which may be due to an enhanced relevance of sad own-age compared with other-age faces. Study 4 explored whether affective responding in terms of facial mimicry is affected by age as well, with a focus on the age of the observer. It revealed an age-related decline in decoding accuracy, but not in affective responding. Taken together, these results demonstrate that response bias and neurofunctional processes may in part explain age effects on decoding accuracy. However, age had little influence on affective responding. Thus, despite difficulties in emotion decoding, these results allow for some optimism regarding intergenerational empathy.

Zusammenfassung

Empathische Reaktionen auf emotionale Gesichtsausdrücke werden vom Alter beeinflusst. In Bezug auf die kognitive Komponente der Empathie wurde eine Einschränkung bei der Erkennung emotionaler Gesichtsausdrücke sowohl für ältere Beobachter als auch für ältere Gesichter berichtet. Manche Studien berichten auch einen Effekt der Alterskongruenz, d.h. eine bessere Erkennung von Emotionen in Gesichtern der eigenen Altersgruppe. Das erste Ziel der vorliegenden Dissertation war es, Mechanismen, die diesen Effekten auf die kognitive Empathie zugrunde liegen könnten, zu untersuchen. Das zweite Ziel war es, zu untersuchen, ob auch die affektive Komponente der Empathie vom Alter beeinflusst wird. Die vorliegende Dissertation basiert auf vier Studien. Studie 1 gibt einen Überblick über frühere Forschungsarbeiten zu Alterseffekten auf die Emotionserkennung und mögliche zugrundeliegende Mechanismen mit einem Fokus auf dem Alter des Gesichts. Zwei dieser Mechanismen wurden in der vorliegenden Dissertation empirisch untersucht. Studie 2 beschäftigte sich mit der Rolle von altersbezogenen Antwortverzerrungen, d.h. Altersunterschieden bei der Attribuierung bestimmter Emotionen. Es konnte gezeigt werden, dass Effekte des Alters der Beobachter und der Gesichter auf die Erkennung von Trauer auf Antwortverzerrungen zurückzuführen waren. Allerdings trat eine bessere Erkennung von Trauer bei der eigenen Altersgruppe auf, die unabhängig von Antwortverzerrungen war. Studie 3 untersuchte die neuronalen Prozesse, die diesem Effekt der Alterskongruenz zugrunde liegen könnten. Bei traurigen Gesichtern wurde ein Effekt der Alterskongruenz für späte neuronale Verarbeitungsstadien gefunden, der möglicherweise eine höhere Relevanz trauriger Gesichter der eigenen im Vergleich zur anderen Altersgruppe widerspiegelt. Studie 4 untersuchte, ob auch affektive Reaktionen, gemessen mit Gesichtsmimikry, vom Alter beeinflusst werden, wobei der Fokus auf dem Alter der Beobachter lag. Ältere Beobachter zeigten eine Beeinträchtigung in der Emotionserkennung, nicht jedoch in den affektiven Reaktionen. Insgesamt weisen diese Ergebnisse darauf hin, dass Antwortverzerrungen und neuronale Prozesse Alterseffekte auf die Emotionserkennung zum Teil erklären können. Allerdings gab es kaum Alterseffekte auf affektive Empathie. Also lassen die Ergebnisse insgesamt trotz Schwierigkeiten bei der Emotionserkennung Optimismus bezüglich der intergenerationalen Empathie zu.

List of Manuscripts

The present dissertation is based on the following manuscripts:

Fölster, M., Hess, U., & Werheid, K. (2014). Facial age affects emotional expression decoding. *Frontiers in Psychology, 5*(30). doi: 10.3389/fpsyg.2014.00030

Fölster, M., Hess, U., Hühnel, I., & Werheid, K. (submitted for publication). Age-related response bias in the decoding of sad facial expressions.

Fölster, M. & Werheid, K. (submitted for publication). ERP evidence for own-age effects on late stages of processing sad faces.

Hühnel, I., Fölster, M., Werheid, K., & Hess, U. (2014). Empathic reactions of younger and older adults: No age related decline in affective responding. *Journal of Experimental Social Psychology, 50*, 136–143. doi:10.1016/j.jesp.2013.09.011

1. Introduction

The human face processing system is extremely specialized and capable of very fine discriminations (see Tovée, 1998, for a review). The human brain contains a specialized system for face processing (Farah, Wilson, Maxwell Drain, & Tanaka, 1995) and already newborn infants prefer looking at faces to looking at other visual objects (Johnson, Dziurawiec, Ellis, & Morton, 1991). This human specialization in face processing may be due to the high importance of the information that faces are conveying for social interactions. For instance, facial expressions reveal important information on the emotional states of our interaction partners (Darwin, 1965/1872). The accurate decoding of these emotional facial expressions is an important aspect of empathic responding (Ickes, 1997).

Previous research suggests that this aspect of empathic responding may be impaired in older age. Specifically, emotional facial expressions were decoded less accurately by older compared with younger observers (see Isaacowitz & Stanley, 2011; Ruffman, Henry, Livingstone, & Phillips, 2008, for reviews). Furthermore, emotional facial expressions seem to be decoded less accurately in older than younger faces (Borod et al., 2004; Ebner, Johnson, & Fischer, 2012; Ebner et al., 2013; Riediger, Voelkle, Ebner, & Lindenberger, 2011). In addition, age congruence between the observer and the face may play a role: In some studies, emotional facial expression were decoded more accurately when the observer and the face belonged to the same age group (*own-age advantage*, Malatesta, Izard, Culver, & Nicolich, 1987; Riediger, Studtmann, Westphal, Rauers, & Weber, 2014; but see Borod et al., 2004; Ebner et al., 2012; Ebner et al., 2013; Ebner, He, & Johnson, 2011; Ebner & Johnson, 2009; Murphy, Lehrfeld, & Isaacowitz, 2010). These deficits may lead to misunderstandings, which may finally impair the quality of intergenerational relationships. Considering the demographic change in western societies, these deficits become increasingly relevant. In Germany, the percentage of individuals in the age of 60 years or older has increased from 17.4% in 1960 to 26.6 % in 2011, and may continue to increase to around 40% in 2060 (Statistisches Bundesamt, 2011).

Previous research mainly focused on the influence of the observers' age on decoding accuracy of emotional facial expressions, whereas the influence of the faces' age and age congruence has seldom been explored. However, interactions involve both an observer and a sender of an emotional message. Thus, in the present dissertation, the influence of the ages of the observer, the face as well as age congruence was examined. The first major aim was to explore the mechanisms that may underlie age effects on facial expression decoding accuracy.

Thus, we compiled previous findings, suggested mechanisms that may underlie these effects and empirically examined two of these mechanisms, that is, age-related response bias and neural processing.

According to Decety and Jackson (2004), empathy involves, next to the cognitive component in terms of the accurate emotion decoding, also an affective component. Thus, the second major aim was to explore whether affective responding is affected by age as well. In the following, I will briefly summarize previous research results and address the open research questions that have been explored in the present dissertation in more detail.

1.1 Cognitive Responding: Response Bias

The majority of previous research used performance measures such as percentages of correct answers that were not corrected for response bias, that is, the unbalanced use of response categories. However, the use of such data may seriously distort results on age effects on decoding accuracy, especially when ambiguous facial expressions are used and guessing rates are high (Wagner, 1993). In the extreme case, if a participant would always decode facial expressions as sad, this would result in 100% accurate answers for sadness. Most relevant to the present dissertation, there may be certain age-related response biases that may, at least in part, account for previous results on age effects on facial expression decoding accuracy.

Concerning the age of the observer, *Socioemotional Selectivity Theory* (Carstensen & Charles, 1998) suggests that older adults are motivated to maximize present emotional wellbeing, due to their limited future time perspective. Younger adults, in contrast, are more motivated to realize future-oriented goals. These motivational differences may lead to age differences in selective attention to those cues that signal positive or negative experience (Mather & Carstensen, 2003), or age differences in intensity thresholds that observers use for positive and negative expressions (Riediger et al., 2011). In line with this assumption, older observers attributed more positive, but less negative emotions to faces (Bucks, Garner, Tarrant, Bradley, & Mogg, 2008; Phillips & Allen, 2004; Riediger et al., 2011). Furthermore, older observers showed a greater bias toward thinking that individuals were feeling happy when they were displaying enjoyment or non-enjoyment smiles (Slessor, Miles, Bull, & Phillips, 2010). This response bias may lower decoding accuracy for negative emotions in older observers. In accordance with this assumption, some studies found the age-related decline in decoding accuracy to be restricted to negative emotions (Ebner & Johnson, 2009; Keightley, Chiew, Winocur, & Grady, 2007; Phillips, MacLean, & Allen, 2002; Williams et al., 2006) and to be statistically explained by an age-related decline in negative affect (Suzuki, Hoshino, Shigemasu, & Kawamura, 2007). Thus, Bucks et al. (2008) suggest that age differences in decoding accuracy may reflect response bias differences rather than a deficit in perceptual discrimination. Contradicting this assumption, some studies did not confirm the attribution of more positive, but less negative emotions in older observers (Riediger et al., 2014; Sasson et al., 2010) and Isaacowitz et al. (2007) found that age differences in decoding accuracy remained significant when response bias was controlled. Thus, the role of age-related response bias for effects of the observers' age on decoding accuracy has not yet been clarified and deserves further investigation.

Concerning the age of the face, morphological features in older faces such as wrinkles, folds and sag of facial muscles (see Albert, Ricanek, & Patterson, 2007; Porcheron, Mauger, & Russell, 2013; for overviews of age-related changes in the face) may resemble certain emotional expressions and lead to the impression of a permanent affective state (Hess, Adams, Simard, Stevenson, & Kleck, 2012). These morphological features in older faces may be mistaken as emotional expressions and lead to biased attributions of certain emotions to older faces. For example, down-turned corners of the mouth which are frequently found in older faces may be misinterpreted as sadness. Furthermore, individuals use stereotypes when decoding ambiguous emotional facial expressions by strangers (Hess et al., 2000). In line with common stereotypes of aging (Cuddy & Fiske, 2002; Gluth, Ebner, & Schmiedek, 2010; Hummert, Garstka, Shaner, & Strahm, 1994), sadness was attributed more frequently to older than younger faces (Malatesta & Izard, 1984). In addition, happy faces were perceived as younger than fearful, angry, disgusted or sad faces (Völkle, Ebner, Lindenberger, & Riediger, 2012) and there was a negative association between the perceived age and happiness of faces (Bzdok et al., 2012). Thus, older age seems to be associated with sadness, whereas younger age seems to be associated with happiness. However, the influence of these response biases on effects of facial age on decoding accuracy has not yet been explored.

Concerning age congruence, older adults themselves may have more favorable stereotypes of aging (see Kite, Stockdale, Whitley, & Johnson, 2005, for a review). Nevertheless, the content of these stereotypes is comparable between younger and older adults (Hummert et al., 1994), suggesting similar influences of age-related stereotypes on emotion attributions for younger and older observers.

1.2 Neural Responding: Event-related Potentials

Due to their high temporal resolution, event-related potentials (ERPs) are an excellent method to explore the neurofunctional processes underlying age effects on emotional facial expression decoding. ERPs are fluctuations of averaged activity in the electroencephalogram, time-locked to an event such as the presentation of a stimulus. Individual ERP components are assumed to reflect different psychological processes. Thus, the examination of ERPs gives an insight into the underlying psychological processes.

Previous research suggests that the ages of the observer, the face, as well as age congruence affect the neural processing of faces (e.g., Wiese, Komes, & Schweinberger, 2012; Daniel & Bentin, 2012). Furthermore, functional magnetic resonance imaging (fMRI) studies suggest that own-age effects on the neural processing may be moderated by the emotional expression of the face (Ebner et al., 2013). However, previous ERP studies exclusively focused on age effects on the processing of neutral faces. As ERPs provide a considerably higher temporal resolution than fMRI, examining own-age effects on ERPs in response to emotional faces would be revealing.

The N170 is an early negative deflection peaking around 170ms over occipitotemporal sites that is associated with the structural processing of faces and whose amplitude is larger for faces than object stimuli (e.g., Bentin, Allison, Puce, Perez, & McCarthy, 1996). Previous research with neutral faces found no own-age effects on the N170; instead, both younger and older observers showed higher N170 amplitudes for older than younger faces (Wiese et al., 2012; Wiese, Schweinberger, & Hansen, 2008), indicating that structural encoding may be more difficult for older faces, both for older and younger observers and that observers focus on details such as wrinkles.

The late positive potential (LPP) is a late enhanced positivity after 300ms over parietal sites that reflects elaborate processing. The LPP amplitude is enhanced for emotional stimuli with high intrinsic relevance (Schupp et al., 2004), and for facial expressions with negative, compared with positive valence and with higher, compared with lower emotional intensity (Duval, Moser, Huppert, & Simons, 2013; Recio, Schacht, & Sommer, 2014). As LPP amplitudes are higher for neutral own-race compared with other-race faces (He, Johnson, Dovidio, & McCarthy, 2009) and own-race and own-age effects on ERPs are partly comparable (Ebner, He, Fichtenholtz, McCarthy, & Johnson, 2011; Wiese et al., 2008, but see Wiese, 2012), LPP amplitudes may be higher for own-age compared to other-age faces. However, own-age effects on the LPP have not yet been explored.

1.3 Affective Responding: Facial Mimicry

According to Decety and Jackson (2004), empathy involves both a cognitive component, that is, the accurate decoding of another persons' emotional state, and an affective component, that is, the affective responding to this emotional state. Thus, considering the above reviewed age effects on cognitive empathy, an important research question is whether age affects affective empathy as well. Effects of the observers' age may be attenuated for affective compared with cognitive empathy, because affective responding is more automatic than the decoding of emotional facial expressions (Hoffman, 2002) and automatic processing may be less affected by aging (Ruffman, Ng, & Jenkin, 2009). Furthermore, Wieck and Kunzmann (2015) suggest that decoding emotional facial expressions is cognitively demanding and related to fluid intelligence (Richter, Dietzel, & Kunzmann, 2011) which declines with age (Salthouse, 1996). Affective empathy, on the other hand, requires emotion regulation (see Eisenberg, 2000, for a review), which is, according to the Socioemotional Selectivity Theory, improved or at least intact in older age (Carstensen & Charles, 1998).

One important aspect of affective responding is *mimicry*, the tendency to facially, vocally or posturally imitate the people with whom we interact (Hess, Philipot, & Blairy, 1999). Mimicry is evoked automatically (Dimberg, Thunberg, & Elmehed, 2000) and may serve two functions (Hess & Fischer, 2013). Firstly, it enhances affiliation and linking (Lakin & Chartrand, 2003), secondly, it fosters understanding another person's emotions (Künecke, Hildebrandt, Recio, Sommer, & Wilhelm, 2014; Lipps, 1907; Neal & Chartrand, 2011; Oberman, Winkielman, & Ramachandran, 2007; Ponari, Conson, D'Amico, Grossi, & Trojano, 2012; Stel & van Knippenberg, 2008). According to Hess and Fischer (2013), there are two theoretical views on the causal processes underlying mimicry. The first one, the *Matched Motor Hypothesis*, assumes that the mere perception of another person's behavior automatically increases the likelihood of engaging in that behavior oneself (Chartrand & Bargh, 1999). The second one considers mimicry as a signal of emotional understanding (Bavelas, Black, Lemery, & Mullett, 1986). Thus, mimicry may serve to communicate to others that we know how they feel (Hess & Fischer, 2013). According to this view, mimicry is sensitive to the specific context, such as the intentions of the expresser and the observer. Supporting this view, the amount of mimicry is influenced by the attitude toward the expresser (Bourgeois & Hess 2008, Study 1) and the perceived similarity with the expresser (Bourgeois & Hess 2008, Study 2, Van der Schalk et al., 2011).

Supporting the idea of attenuated effects of the observers' age for affective empathy, previous research found no effect of the observers' age on mimicry (Bailey & Henry, 2009; Bailey, Henry, & Nangle, 2009). However, previous mimicry studies only analyzed anger and happiness and only used younger faces. Considering the emotion-specific age effects on decoding accuracy, it would be desirable to extent this research to a broader range of emotions. Furthermore, it would be desirable to vary the age of the face because, according to the Matched Motor Hypothesis, the impaired perception of emotional expressions may reduce mimicry to older faces. In addition, as mimicry is influenced by the perceived similarity with the expresser (Bourgeois & Hess, 2008), mimicry might be enhanced for own-age compared with other-age faces.

1.4 Research Questions

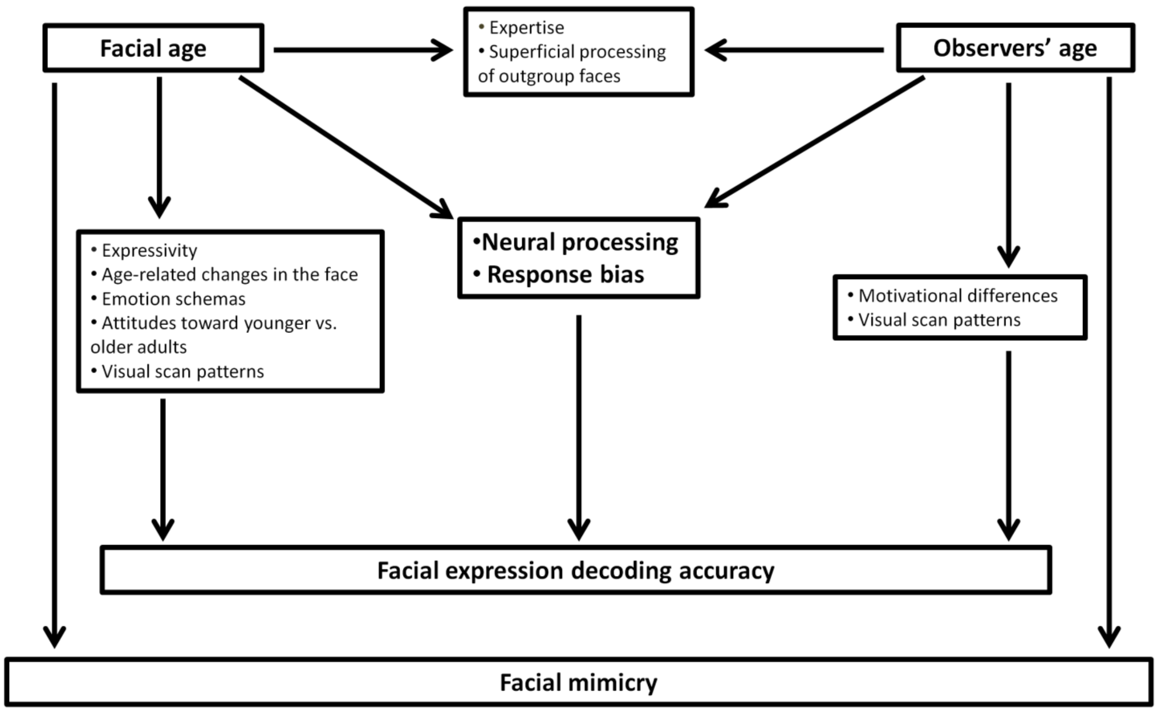

Figure 1. Overview on mechanisms that may underlie age effects on facial expression decoding, adapted from Fölster, Hess, & Werheid (2014). Effects that were examined in the present dissertation are written in bold.

Figure 1 gives an overview on potential mechanisms underlying age effects on facial expression decoding and highlights the aspects that have been examined in the present dissertation. Age effects on cognitive, neural, and affective responding to emotional facial expressions were examined in younger (aged 30 and below) and older adults (aged 62 and above). Although two review articles on effects of observers' age on decoding accuracy and potential underlying mechanisms have been published (Isaacowitz & Stanley, 2011; Ruffman et al., 2008), there was no review giving a systematic overview on effects of facial age. Thus, the aim of the first part of the present dissertation was to compile and evaluate findings on effects of facial age on decoding accuracy and potential underlying mechanisms, and to identify unresolved research questions. The aim of the second and third part of the present dissertation was to empirically examine two mechanisms that may underlie age effects on decoding accuracy. Study 2 explored the role of age-related response bias. Study 3 explored age effects on the neural processing of emotional faces. Specifically, we wanted to explore whether age effects on ERPs to faces emerge during earlier perceptual or later evaluative processing stages, and whether age effects are moderated by the emotional expression of the face, with a focus on age congruence. The aim of the fourth part of the present dissertation was to explore whether affective empathy in terms of facial mimicry is affected by age as well, with a focus on the age of the observer. Specifically, the present dissertation was guided by the following research questions.

Concerning the observers' age:

1. Is the age-related decline in decoding accuracy for negative emotions due to age-related response bias as suggested by the Socioemotional Selectivity Theory?
2. Does the age of the observer influence affective empathy in terms of facial mimicry?

Concerning facial age:

3. Which mechanisms are underlying the lower decoding accuracy for older faces?
4. Is the effect of facial age on decoding accuracy due to response bias?

Concerning age congruence:

5. Does age congruence affect the neural processing of emotional faces? Specifically:

   (5a) Does age congruence affect earlier or later neural processing stages?

   (5b) Are effects of age congruence on the neural processing of faces moderated by emotional expression?

2. Summary of Studies

2.1 Study 1: Facial Age Affects Emotional Expression Decoding

The aim of this review article was to compile previous findings on age effects on emotional expression decoding accuracy and possible underlying mechanisms and identify unresolved research questions, with a focus on the age of the face. Age-related changes in flexibility and controllability of muscle tissue may lead to lower expressivity in older adults when they pose emotional facial expressions (Levenson, Carstensen, Friesen, & Ekman, 1991), possibly explaining the lower decoding accuracy for posed (e.g., Ebner et al., 2012), but not spontaneous expressions in older faces (Malatesta, Izard, Culver, & Nicolich, 1987). In addition, due to a lower frequency of contact to older than younger adults, emotion schemas may be better calibrated to decode emotions in younger than older faces (Macchi Cassia, 2011). Furthermore, as reviewed above, age-related changes in the face, such as wrinkles and folds may make older faces' expressions more ambiguous and reduce their signal clarity (Ebner & Johnson, 2009; Hess et al., 2012). Due to these age-related changes, morphological features in older faces may also resemble emotional facial expressions (Hess, Adams, & Kleck, 2008), possibly leading to a biased emotion attribution to older faces. Attitudes and stereotypes toward the elderly may further bias the attribution of emotions to older faces (Malatesta & Izard, 1984; Matheson, 1997), possibly leading to higher decoding accuracy for emotions corresponding to these stereotypes such as sadness, and lower decoding accuracy for emotions contradicting these stereotypes, such as happiness. Furthermore, observers focus more on the eye region of older faces and the mouth region of younger faces (Firestone, Turk-Browne, & Ryan, 2007, but see He, Ebner, & Johnson, 2011). As the mouth region is especially important for the decoding of happiness and disgust (Calder, Young, Keane, & Dean, 2000), these differences in visual scan patterns may explain the emotion-specific lower decoding accuracy for disgust and happiness in older faces; however, results on this mechanism are mixed. Finally, studies examining neurofunctional processes suggest a more controlled processing (Ebner, He, Fichtenholtz, et al., 2011) and a more difficult structural encoding of older compared with younger faces (Wiese, 2012; Wiese et al., 2008).

The own-age advantage on decoding accuracy reported in some studies (Malatesta et al., 1987; Riediger et al., 2014) may be explained by two mechanisms: firstly, according to *social cognitive theories*, faces of outgroup-members are cognitively disregarded and more superficially processed (Sporer, 2001). Secondly, more experience and contact with same-aged individuals may lead to higher expertise (Rhodes & Anastasi, 2012) and familiarity with the morphology and expressive style of the own age group (Malatesta et al., 1987). According to the *Categorization-Individuation Model* (Hugenberg, Young, Bernstein, & Sacco, 2010), both factors may play a role.

2.2 Study 2: Age-related Response Bias in the Decoding of Sad Facial Expressions

As reviewed in Study 1, age-related changes in the face and stereotypes may bias the attribution of emotions to older faces. In Study 2, the influence of this age-related response bias on decoding accuracy was analyzed. We expected sadness to be more frequently attributed to older than younger faces. Furthermore, as reviewed above, due to motivational differences suggested by the Socioemotional Selectivity Theory (Carstensen & Charles, 1998), we expected older compared with younger observers to attribute more positive emotions, and less negative emotions. Finally, we expected age effects on decoding accuracy to be reduced when age-related response bias was controlled.

In the first step, we created silent video clips of 16 older and 18 younger actors talking about emotional (fear, disgust, anger, sadness, happiness) biographical episodes. In the next step, older and younger observers viewed these video clips and decoded the emotional expressions. We analyzed effects of facial age, observers' age and age congruence on raw hit rates that have been used in the majority of previous studies. We further analyzed age-related response bias and unbiased hit rates that had been corrected for age-related response bias according to Wagner (1993) and inspected the differences to the raw hit rates.

As expected, age effects differed between raw hit rates and unbiased hit rates, indicating that results for raw hit rates were distorted by response bias. Raw hit rates suggested higher decoding accuracy for sadness in older faces and disgust in younger faces. Furthermore, they suggested higher decoding accuracy for younger than older observers for sadness and fear. For sadness, these effects of the faces' and observers' age vanished when response bias was controlled. Thus, these age effects on decoding accuracy were due to the expected more frequent attribution of sadness to older than younger faces, and by younger than older observers. In addition, raw hit rates suggested an own-age advantage for sadness and disgust. When response bias was controlled, this own-age advantage vanished for disgust, but remained significant for sadness for older observers.

These results suggest that, as expected, age effects on decoding accuracy were, in part, due to response bias. This underlines the importance to correct for such bias when analyzing age effects on decoding accuracy, especially when spontaneous or ambiguous facial expressions are used which lead to higher guessing rates and a stronger influence of response bias.

2.3 Study 3: ERP Evidence for Own-age Effects on Late Stages of Processing Sad Faces

The aim of Study 3 was to explore the neurofunctional processes underlying the own-age effect on decoding accuracy for sadness that has been found in Study 2. As previous ERP research exclusively focused on the processing of neutral faces, we investigated whether own-age effects on ERPs are moderated by the emotional expression of the face. Furthermore, we investigated whether age congruence affects earlier perceptual or later evaluative processing stages. We also examined the role of quality and quantity of contact and identification with the own vs. the other age group.

We recorded the electroencephalogram while 19 younger and 19 older observers viewed pictures of younger and older sad and happy faces in three intensities (10%, 50%, 90%). Age effects on one earlier (N170) and one later (LPP) ERP were analyzed. Quality and quantity of contact and identification with the own vs. the other age group were assessed via questionnaires.

We found that sad faces of the own age group elicited higher LPP amplitudes than those of the other age group, possibly reflecting increased relevance (Schupp et al., 2004) of sad own-age faces. In line with previous results for neutral faces (Wiese et al., 2012; Wiese et al., 2008), there was no own-age effect on the N170. Thus, age congruence affected later, but not earlier neural processing stages. In addition, we found an own-age advantage in decoding accuracy for sad expressions in low intensity (10%). These own-age effects on LPPs and decoding accuracy were significant for older, but not younger observers, possibly because age is a more salient and self-relevant feature for older than younger adults (Ebner et al., 2013). The own-age effect on LPPs correlated with the own-age effect for the quality, but not the quantity of contact or identification with the own age group, suggesting that the higher quality of contact to own-aged individuals may be a factor underlying the own-age effect in neural processing. We did not find an own-age effect for happiness, possibly because a smile is a strong affiliation signal that is relevant, irrespective of group membership (van der Schalk et al., 2011).

Although this was not the focus of our study, it is worth mentioning that we also confirmed main effects of the observers' and faces' ages that have been found in previous studies for neutral faces. In line with previous research (Chaby, George, Renault, & Fiori, 2003; Gao et al., 2009), N170 amplitudes were larger for older than younger observers, possibly due to an enhanced sensitivity for visual stimuli (Gao et al., 2009) or a decrement of neural adaptation with aging (Chaby et al., 2003). Further in line with previous research (Wood & Kisley, 2006), LPP amplitudes were smaller for older observers, which may be due to an overall dampening of the processing of emotional images. We also confirmed previous reports of higher N170 amplitudes for older than younger faces, which may be due to a more difficult structural encoding for older faces, or observers focusing on details such as wrinkles and folds (Wiese et al., 2012; Wiese et al., 2008). These effects of the faces' and the observers' ages were not moderated by the emotional expression of the faces.

2.4 Study 4: Empathic Reactions of Younger and Older Adults: No Age Related Decline in Affective Responding

The aim of this study was to investigate whether age affects the affective component of empathy in a similar vein as the cognitive component. We investigated age effects on facial mimicry, as a measure for affective empathy, and on decoding accuracy, as a measure for cognitive empathy, with a focus on the age of the observer. Based on previous research reviewed above, we expected an age-related decline in decoding accuracy, but not in facial mimicry.

We selected a subset of the videos of spontaneous expressions that were developed in Study 2, consisting of anger, disgust, sadness and happiness expressions by those four younger and four older actors that achieved the highest decoding accuracy in Study 2. Those videos were presented to 39 younger and 39 older female observers. Observers' facial mimicry was assessed via facial electromyogramm (EMG). Furthermore, observers decoded the emotional facial expressions.

As expected and in line with previous research (Bailey & Henry, 2009; Bailey et al., 2009), mimicry patterns did not differ between younger and older observers for sadness, anger and happiness, although older observers showed lower decoding accuracy for happiness and sadness. Interestingly, only older observers mimicked disgust. These results suggest that affective responding toward emotional facial expressions does not decline in older age; instead, older observers showed even more mimicry for disgust. As a possible explanation for this latter finding, younger observers may be less willing to engage with disgust stimuli to protect themselves because they entrain larger cognitive costs when regulating disgust (Scheibe & Blanchard-Fields, 2009). Alternatively, younger observers may have confused disgust expressions with anger, as they showed anger expressions in response to disgust. Although this was not the focus of the study, it is interesting to note that there were no effects of facial age or age congruence on facial mimicry. We concluded that intergenerational interactions may not be as impaired as findings solely based on decoding accuracy have suggested.

3. General Discussion

To sum up, the aims of the present dissertation were to compile findings on mechanisms underlying age effects on decoding accuracy, and examine two of these mechanisms, specifically, age-related response bias and neural processing. Furthermore, we examined whether affective responding to emotional facial expressions is affected by age as well. In the following, I will first briefly summarize and integrate the results of the present dissertation. After that, I will discuss the limitations of the present dissertation and suggest open research questions that might be addressed by future research. Finally, I will summarize the conclusions that can be drawn based on the results.

3.1 Integration of Findings

3.1.1 Observers' age

Concerning the observers' age, one aim of the present dissertation was to explore whether the age-related decline in decoding accuracy is due to age-related response bias as suggested by the Socioemotional Selectivity Theory. Study 2 revealed an age-related decline in decoding accuracy for sadness, disgust and happiness. For sadness, this age-related decline vanished when response bias was controlled. Thus, this seemingly less accurate decoding of sadness by older observers was due to a less frequent attribution of sadness by older than younger observers. This result confirms predictions by the Socioemotional Selectivity Theory, which assumes that older adults may be less motivated to attend to other persons' negative emotional states (Carstensen & Mikels, 2005) in order to maintain a positive emotional state. This result is in accordance with previous reports of age differences in decoding accuracy being statistically explained by age differences in negative affect (Suzuki et al., 2007, but see Isaacowitz et al., 2007). However, age differences remained significant for disgust and happiness, suggesting that response bias is not the only mechanism underlying observers' age effects on decoding accuracy. Study 3 revealed smaller LPP amplitudes for older than younger observers in response to emotional faces, suggesting an overall dampening in the neural processing of emotional faces (Wood & Kisley, 2006). Thus, age differences in the neural processing of emotional faces might be another mechanism underlying age differences in decoding accuracy.

Another aim of the present dissertation was to explore whether affective empathy is affected by the age of the observer as well. Despite the above reviewed age differences in decoding accuracy and in neural processing, Study 4 revealed no age-related decline in affective empathy in terms of facial mimicry. Contrariwise, only older observers mimicked disgust and there were no age differences for happiness, anger and sadness. Thus, despite difficulties in decoding emotional facial expressions and dampened neural processing of emotional faces, affective responding seems to remain intact in older age. These results are in accordance with previous reports of mimicry being unaffected by age (Bailey & Henry, 2009; Bailey et al., 2009) and support the assumption that implicit, automatic processes are less affected by age than the decoding of facial expressions (Ruffman et al., 2009). Furthermore, the dissociation between ERP and mimicry results is in line with previous reports of dampened neural processing of emotional images, but sustained subjective experiences in older adults (Wood & Kisley, 2006).

In addition, these results suggest that the accurate decoding of emotional expressions may not be a prerequisite for affective responding. This assumption is supported by some previous reports of mimicry being independent from decoding accuracy (Blairy, Herrera, & Hess, 1999; Hess & Blairy, 2001). However, this independence is subject to controversial debate (Künecke et al., 2014; Neal & Chartrand, 2011; Oberman et al., 2007; Ponari et al., 2012). Our results suggest that mimicry and decoding accuracy are at least differentially affected by age. Thus, age may only affect the cognitive, but not the affective component of empathy. This assumption is further supported by previous research reporting no age-related decline for alternative measures for affective empathy, such as self-reported affective empathy (Bailey, Henry, & Von Hippel, 2008), sharing of emotions (Richter & Kunzmann, 2011; Wieck & Kunzmann, 2015), sympathy (Richter & Kunzmann, 2011; Sze, Gyurak, Goodkind, & Levenson, 2012; Wieck & Kunzmann, 2015), autonomic responses and prosocial behavior (Sze et al., 2012). As a possible explanation, Wieck and Kunzmann (2015) suggest that fluid intelligence, which plays an important role for cognitive empathy (Richter et al., 2011), declines in older age (Salthouse, 1996), whereas emotion regulation abilities, which play an important role for affective empathy (see Eisenberg, 2000, for a review), are sustained or enhanced in older age (Carstensen & Charles, 1998). Thus, although the correct labeling of emotional expressions may decline in older age, sympathy and affective responding seem to remain intact.

3.1.2 Facial age

One aim of the present dissertation was to compile previous findings on mechanisms that may underlie effects of facial age on decoding accuracy. As outlined in Study 1, lower expressivity in older faces, age-related changes in the face, less elaborated emotion schemas for older faces, negative attitudes toward older adults and different visual scan patterns and neural processing of older compared with younger faces may explain the lower decoding accuracy for older faces. Furthermore, age-related stereotypes and changes in the face may bias emotion attributions.

Another aim of the present dissertation was to empirically explore the influence of these biased emotion attributions on decoding accuracy. Study 2 revealed that sadness and fear were more accurately decoded in older faces, whereas disgust was more accurately decoded in younger faces. For sadness, this age effect vanished when response bias was controlled. Thus, effects of facial age on decoding sadness were due to a more frequent attribution of sadness to older than younger faces. This response bias may be due to common stereotypes of older adults being sad (Gluth et al., 2010), or due to morphological features in older faces resembling sad expressions.

Nevertheless, as age differences remained significant for fear and disgust, response bias is not the only mechanism underlying effects of facial age on decoding accuracy. Results of Study 3 suggest that the neural processing of younger and older faces may differ. In line with previous results for neutral faces (Wiese et al., 2008), N170 amplitudes were higher for older than younger emotional faces. This result suggests that structural processing is more difficult for older faces or that observers focus on details such as wrinkles and folds in older faces (Wiese et al., 2008), which may distract them from the emotional expression. However, in Study 2 and 4, we found that emotions were not generally decoded less accurately in older faces. This result is in line with some previous studies using spontaneous dynamic expressions (Malatesta et al., 1987; Riediger et al., 2014, but see Murphy et al., 2010, Richter et al., 2011). As a possible explanation, the impact of morphological features reducing the signal clarity of emotional facial expressions may be attenuated for dynamic expressions (Sparko & Zebrowitz, 2011).

On a side note, we found no effects of facial age on mimicry in Study 4. Thus, although facial age affected emotional expression decoding and neural processing, it did not affect affective responding. This result contradicts predictions of the Matched Motor Hypothesis, according to which the impaired perception of emotional expressions in older faces should reduce mimicry to older faces. Thus, only the cognitive component of empathy toward older adults' expressions is reduced, whereas affective empathy toward older and younger adults' expressions may be similar.

3.1.3 Age congruence

Study 2 revealed an own-age advantage in decoding accuracy for sadness and disgust when raw hit rates were used as outcome measure. When response bias was controlled, the own-age effect vanished for disgust, but not for sadness. Thus, for disgust, the own-age effect was due to response bias. For sadness, however, the own-age effect might be explained by other mechanisms such as neural processing, which was explored in Study 3. Specifically, the aim of this dissertation was to explore whether age congruence affects earlier perceptual or later evaluative neural processing stages and whether effects of age congruence on the neural processing of faces are moderated by the emotional expression of the face. Study 3 revealed an own-age effect on late processing stages (LPP) for sad faces, suggesting increased relevance of own-age compared with other-age sad faces. In contrast, there were no own-age effects for happy faces or earlier processing stages (N170). This finding suggests that age congruence influences later processing stages that are commonly associated with motivational relevance of the facial stimuli, but not earlier processing stages that are associated with their structural encoding. This own-age effect correlated with the quality, but not the quantity of contact or identification with the own vs. the other age group. Thus, the higher quality of contact to the own age group may be a factor underlying the own-age effect in neural processing of sad faces. Both the own-age effects on decoding accuracy and ERPs were significant for older, but not younger observers. As outlined in Study 3, this result is in line with previous results of enhanced own-age effects on neural processing for older observers (Ebner et al., 2013; Wright et al., 2008) and supports the assumption by Ebner et al. (2013)

that age is a more salient and relevant feature for older adults who may be more frequently reminded of their age because of age-related declines in various domains of functioning.

Interestingly, own-age effects on neural processing and decoding accuracy in Studies 2 and 3 were moderated by the emotional expression of the face. Specifically, own-age effects only occurred for sadness, but not for the remaining emotions, suggesting that these own-age effects may be specific for sadness. The emotion-specific own-age advantage in decoding accuracy might be explained by age–related "dialects" in facial emotion communication. Elfenbein, Beaupré, Levesque, and Hess (2007) found that different cultural groups may activate different muscles for the same expressions. These differences were most pronounced for emotions that are primarily elicited by social events, such as sadness. Such dialects may as well exist for different age groups. In line with this assumption, younger and older adults slightly differed in their nonverbal expression of sadness (Malatesta & Izard, 1984). As an alternative explanation, sadness is likely expressed more intensely in the presence of friends, compared with strangers. In this regard, sadness may differ from disgust, anger and happiness (Wagner & Smith, 1991). Since we usually have more friendships to members of our own age group (Hagestad & Uhlenberg, 2005), we may be more frequently exposed to expressions of sadness in own-age faces. This may lead to especially pronounced own-age effects in familiarity of emotional facial expressions for sadness. Another alternative explanation suggested in Study 3 is that in-group effects may be attenuated for happiness because a smile is a strong affiliation signal that may overrule group boundaries (van der Schalk et al., 2011). Bourgeois and Hess (2008) suggest that empathizing with a sad emotional state, on the other hand, may be especially costly, because it may demand taking care of the observed person. Emotional contagion may require emotion regulation, leading to additional emotional costs. In this respect, sadness may be more costly than the remaining emotions and thus, in-group effects may be especially likely to occur for sadness. In line with this assumption, Bourgeois and Hess (2008) found in-group effects on mimicry for sadness, but not for happiness. Thus, older adults may avoid recognizing sadness in younger adults in order to reduce emotional costs. However, in conflict with this account, we did not find own-age effects on mimicry of sadness. Thus, more research is required to answer the question of whether own-age effects are especially pronounced for sad faces.

Contradicting these results, no own-age effect on decoding accuracy was found in Study 4. This seemingly discrepant result might be due to the varying difficulty of the stimuli. Thus, own-age effects might only occur when expressions that are very difficult to decode are used. In Study 4, decoding accuracy was higher than in Study 2 because we only used a subset of those stimuli that reached comparatively high decoding accuracy in Study 2. Further in line with this explanation, Study 3 confirmed an own-age effect on decoding accuracy for sadness for older observers, but only for expressions of low intensity. In addition, this explanation is further supported by previous research. Specifically, an own-age effect was found when decoding accuracy was very low such as in the study by Malatesta et al. (1987), but not when it was higher such as in the majority of previous studies (Borod et al., 2004; Ebner, He, & Johnson, 2011; Ebner & Johnson, 2009; Ebner et al., 2012; Ebner et al., 2013). In Study 3, we suggest that observers need more cognitive resources to decode difficult expressions, possibly leading to a higher influence of motivational factors. So far, this explanation is only speculative and needs further empirical investigation.

On a side note, despite these own-age effects on decoding accuracy and neural processing, no own-age effects on mimicry were found in Study 4. This result seems peculiar, as previous research found in-group effects on mimicry, even when these groups were based on comparatively arbitrary characteristics such as students' subject of study (van der Schalk et al., 2011), political attitudes or being a basketball player (Bourgeois & Hess, 2008). Thus, our results contradict the view of mimicry being moderated by the perceived similarity with the expresser. Furthermore, they are in conflict with the argumentation above that own-age effects on decoding accuracy and neural processing of sadness are due to observers trying to limit emotional costs, because mimicry of sadness should be costly as well. As Study 4 describes the first mimicry study varying both the faces' and the observers' age, further research is needed to clarify the question whether there are own-age effects on mimicry. A recent study suggests that own-age effects on mimicry may occur in real-life interactions (Kuszynski, Hühnel, Hess, & Asendorpf, submitted for publication). However, only younger observers and only anger and happiness, but not sadness were examined in this study. Thus, future research should examine own-age effects on mimicry of sadness in real-life interactions.

3.2 Limitations and Outlook

Compared with the majority of previous research, the stimuli that were used in the present dissertation were more similar to emotional expressions encountered in everyday life. Specifically, spontaneous, dynamic expressions were used in Studies 2 and 4 and expressions varying in intensity in Study 3. Nevertheless, future research should examine how age affects responses to emotional facial expressions in everyday interactions. For example, we are often confronted with expressions that are even more mixed and subtle and whose interpretation may be even stronger influenced by stereotypes or the own affective or motivational state. Thus, the influence of response bias on decoding accuracy may be even stronger in everyday interactions. Research in this area is still sparse. To our knowledge, so far only two studies (Blanke, Rauers, & Riediger, 2015; Kuszynski et al., submitted for publication) examined real-life interactions between younger and older adults. These studies suggest that findings obtained with pictures or videos may not always be transferrable to real-life interactions. Thus, more research examining age effects on emotion communication in laboratory situations that are more similar to everyday life is needed.

Furthermore, the present dissertation only examined nonverbal emotion communication, although verbal communication is an important aspect of emotion communication and may be differently affected by age. In addition, age effects on decoding of emotions may be attenuated when nonverbal as well as verbal information is provided (Blanke et al., 2015; Richter et al., 2011). Thus, future research should also examine age effects on decoding accuracy for emotions communicated via prosody and the verbal content.

In addition, the assessment of cognitive empathy was limited to the accurate decoding of emotional facial expressions. However, according to Ickes, Stinson, Bissonnette, and Garcia (1990), empathic accuracy (a concept which is closely related to cognitive empathy) comprises the accurate understanding of both the emotions and thoughts of another person. Furthermore, the assessment of affective empathy was limited to facial mimicry. Emotional congruence and sympathy may represent alternative measures for affective empathy. To the best of my knowledge, effects of facial age and age congruence on these measures for affective empathy have not yet been explored. Thus, future research should examine effects of the ages of the observer, the face and age congruence on the ability to infer thoughts and on emotional congruence and sympathy.

The sample of participants in the present dissertation was limited to younger adults in the age of 18 to 30 years, and older adults in the age of 62 years and older. It would be desirable to examine middle-aged adults as well to be able to explore the continuous development of empathy. In addition, the present dissertation’s cross-sectional design does not allow the disentangling of the effects of age and cohort. Longitudinal studies examining the development of empathy would be desirable.

Finally, future research may examine how age-related deficits in emotion decoding can be reduced. Considering the demographic change in western societies, this research question is highly relevant. Previous research suggests that the ability to decode emotional facial expressions may be enhanced by training via feedback (Elfenbein, 2006). Thus, training programs for older adults may reduce deficits related to the observers' age. Furthermore, training programs for the decoding of expressions in older faces may reduce deficits related to facial age. In addition, previous research suggests that participating in the "aging game" which simulates the experience of disabilities associated with older age may enhance younger adults' empathy for older adults (Pacala, Boult, Bland, & O'Brien, 1995; Varkey, Chutka, & Lesnick, 2006). These training programs may be especially helpful for individuals who are working with older adults, such as geriatric nurses or doctors. Thus, the development of training programs to enhance intergenerational empathy might be another promising aim for future research.

3.3 Summary and Conclusions

The present dissertation contributes to the understanding of intergenerational empathy. Firstly, it provides novel insights on potential mechanisms underlying age effects on cognitive empathy. Secondly, it expands previous research on age effect on empathy by examining both the affective and the cognitive component of empathy. The results suggest that age-related response bias and neurofunctional processes may underlie age effects on emotional facial expression decoding. Thus, age affects the attribution of emotions to facial expressions, possibly leading to misinterpretations of emotions in interactions involving older adults. Furthermore, our results suggest that sad facial expressions of the own-age group may be more relevant for older adults than those of other age groups. Thus, emotional expressions may be misinterpreted or ignored in intergenerational interactions, possibly impairing intergenerational emotion communication. However, age only had little influence on affective empathy. Thus, in sum, these results allows for some optimism regarding the quality of intergenerational interactions.

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6. Eidesstattliche Erklärung

Hiermit erkläre ich an Eides statt,

1) dass ich die vorliegende Arbeit selbständig und ohne unerlaubte Hilfe verfasst habe,

2) dass ich mich nicht anderwärts um einen Doktorgrad beworben habe und noch keinen Doktorgrad der Psychologie besitze,

3) dass mir die zugrunde liegende Promotionsordnung vom 3. August 2006 bekannt ist.

Berlin, den 24.06.2015

Mara Fölster